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ABSTRACT

The purpose of this study was to address issues related to the kind and degree of relationship between mathematical achievement and attitude toward mathematics. Data were gathered on a number of attitudes from 145 college students in a basic mathematics course. Attitudinal data were gathered by means of a six-page questionnaire, essay questions, and interviews with selected students. To assess students' mathematical ability, two diagnostic tests were administered; a test of the students' conceptual skills in mathematics and a test of manipulative mathematics skills. The findings from this study support the conclusion that, in general, attitudes are not significant predictors of performance in a mathematics course. However, the study produced evidence that one cause for these generally low correlations between attitude and performance may be that attitudes interact differently for different groups of students--for example, males and females, and students of different ability. Finally, the study proposed a new framework for investigating the influence of attitude on performance by looking at different types of students and how their attitudes might be undermining their ability to do well in mathematics courses. (PK)

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Attitudes and Beliefs about Learning, about Mathematics,
and about Self Which Most Seriously Undermine
Performance In Mathematics Courses

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Introduction

All mathematics teachers, from first grade through college, have encountered, in virtually every class, varying numbers of students who do poorly. Some of these students seem to have done poorly because they have given up on themselves; others still try to do well but their effort seems half-hearted, as if they were almost expecting to fail or do poorly; yet other students seem to try very hard but their effort simply does not translate to success in the course. Both teachers' experiences and researchers' interviews and questionnaires have pointed to a number of attitudes and beliefs which may be damaging to students. Consider just a few examples of "poor" attitudes and beliefs: "some people just don't have mathematical minds; those who don't just can't learn math;" "if you can't see how to solve a problem within a minute, then you might as well give up;" "the key to mathematics lies in learning the right formulas and tricks;" "I don't worry about understanding what I'm doing as long as I can get the right answer;" "you have to produce a mathematical solution in a math class." I believe that most high school and college mathematics teachers would agree that students' attitudes and beliefs about learning, about mathematics, and about self often have significant impact on their ability to learn mathematics.

To date, however, research on the influence of affective variables on mathematics achievement has produced mixed and inconclusive results. In a review of studies on affective variables, Aiken (1976) noted that many studies have found significant but low positive correlations between attitude scores and mathematics achievement scores. Nine years later, Dick (1985) reported that "there has been little research convincing enough to

indicate that attitudes are an important influence on mathematics achievement. . . If we are searching for predictors of mathematics achievement, then attitudes toward mathematics appear to be weak ones at best" (p. 3). However, researchers continue to explore this area for, as Kulm (1980) states, "the commonsense feeling that achievement ought to depend heavily on attitudes stimulates the search for a clear, simple relationship between these variables" (p. 366).

Several possibilities about attitudes and beliefs are possible. First, it is possible that students' attitudes and beliefs do not affect performance as powerfully as had once been thought, that much or most of a person's success in mathematics is simply explained by the student's cognitive and metacognitive skills and ability.

Another possibility is that there are significant connections between attitudes and achievement but they have not yet been demonstrated because of theoretical and methodological problems in the affective domain. From a theoretical perspective, there is little understanding of what "affect" means. McLeod (1985) has noted that most theoretical models of problem solving performance do not even include affective factors. Several researchers see theory development (both theoretical constructs for various attitudes and models concerning the relationship between attitudes and achievement) as a top priority (McLeod, Reyes, Fennema, & Surber, 1985; Reyes, 1984). From a methodological perspective, many researchers have also pointed out various difficulties in defining and measuring attitudes, and several recommendations have been made to address these problems (Fennema & Behr, 1980; Kulm, 1980; Reyes, 1984).

A third possibility is that the relationships between attitudes and

achievement may not be clear and simple, i.e., that poor attitudes are directly related to low achievement and good attitudes are directly related to high achievement. There is a rich and growing literature concerning the differences in the relationship between attitudes and achievement for males and females (Fennema & Sherman, 1978; Licht & Dweck, 1983; Dick, 1985). There is also a large literature from the field of psychology which might enable us to better understand why certain students are less successful than others in mathematics, for example, learned helplessness, defensive attributions, and the complex nature of anxiety.

Purpose of the present study

The present study was designed to address the issues raised above, in the context of a college remedial mathematics course in which there is a strong focus on problem solving, by focusing on two questions:

- (1) If it is true that affective variables are poor predictors of achievement, will a constellation of affective variables including students' beliefs about mathematics and about learning mathematics produce greater significance?
- (2) Will different kinds of students (e.g., males and females, students of different ability, etc.) show differential patterns between attitudes and achievement?

Significance of the study

Increasing our understanding of the relationship between attitudes and performance in mathematics is even more important today because of the increased attention being given to problem solving in the mathematics

curriculum (NCTM, 1980a, 1980b) and because of the rising number of students enrolled in remedial mathematics classes in four year colleges (Coleman & Selby, 1982). By the time a person arrives at the university, he or she has had at least ten years of mathematics. Most of those placed in remedial mathematics courses have experienced previous problems in learning mathematics although many have taken three or four years of high school math and had thought that they "knew the basics." Also, many of the students in the course have done well in their other subjects. In any case, for many of the students, being placed in a remedial math class carries varying degrees of embarrassment, humiliation, frustration, and anger. Although many students do well in the class, the situation for those who do poorly is critical. Many see this as their "last chance" to learn the basics and many have come to the point where trying harder and studying more, by themselves, is simply not enough.

Description of the study

A comprehensive study was conducted during the fall semester of 1985 in which data on a number of attitudes was gathered from 145 students in seven sections of a basic mathematics course at the University of Massachusetts at Amherst in which a strong focus was placed on problem solving. Data were gathered from three sources. First, a six page questionnaire was administered on the second day of the semester. From this questionnaire data were obtained on eleven attitudes in five attitude groups. The attitudes and the symbols used to represent them are: level of anxiety (ANX) , perceived usefulness of mathematics (USE) , two measures of confidence-- confidence in ability to learn mathematics (CON), and the

student's predicted grade in the class (PRED); students' attributions for success and failure in learning mathematics (ATTS) and (ATTF); and four different measures of students' beliefs about learning mathematics: beliefs about the nature of mathematics (MATH), beliefs about the nature of mathematical intelligence (IEM), students' goals in the course--competence or performance (CP), and students' beliefs about the role of the student and teacher on a continuum from passive to active (ACTIVE).

Second, several essay questions were given as an assignment during the second week of the course. These questions were designed to measure students' beliefs about the role of memorization and understanding in the learning process (MEM). Two of these essay questions are shown in Appendix A.

Third, sixteen students doing poorly in the course were interviewed after the first exam. Given the consistently low correlations between attitudes and achievement reported in the literature, the interviews were conducted because it was felt that such qualitative data might provide clues for better understanding the relationship between attitudes and achievement in the course.

To assess the students' mathematical ability, two diagnostic tests were administered, a test of the students' conceptual skills in mathematics (DIAGC) and a test of manipulative mathematical skills (DIAGM). The measure of performance used in the study (EXAM) was a weighted average of the students' scores on the three exams in the course.

Description of the attitudes

Because of the nature of the course (problem solving) and the nature of

the students (remedial), it was felt that a key to poor performance in the course might lie in poor beliefs about mathematics and about learning mathematics. The five beliefs measured in the study are briefly discussed in this section. The first belief concerns the students' conceptions of intelligence. Carol Dweck and her associates (see Dweck & Elliott, 1983; Dweck & Bempechat, 1983) have proposed an achievement motivation model in which students hold, to differing degrees, two operating conceptions of intelligence. Students subscribing predominantly to an 'entity' conception tend to view intelligence more as a fixed, static quality while students subscribing predominantly to an 'incremental' conception tend to view intelligence as a quality which is increased through one's own behavior. Dweck's findings with younger children support the contention that students holding predominantly entity conceptions of intelligence tend to be more vulnerable in classroom settings than students holding predominantly incremental conceptions of intelligence.

The second belief measured is seen by Dweck as closely related to students' conceptions of intelligence and concerns the students' learning goals. Dweck has hypothesized that students holding predominantly incremental views of intelligence will be motivated more by goals of increasing their competence in mathematics, while students holding predominantly entity views of intelligence will be motivated more by performance goals, that is, their focus will be more on either getting a good grade or, if their confidence is very low, on avoiding a low grade.

The third belief concerns the student's conceptions of the role of memorization and understanding in the learning process. Students at one end of the spectrum tend to equate learning with memorizing while students

at the other end of the spectrum acknowledge that memorizing a formula or being able to apply a formula or technique to obtain an answer is often only the first step to mastering or understanding the concept.

The fourth belief measured has to do with the students' beliefs concerning the role of the teacher and student in the learning process on a continuum of passive to active. A student at one end of the continuum subscribes to the belief that it is the teacher's role "to teach." In other words, when the student is having difficulty with a concept or a problem, it is the teacher's responsibility to explain to the student, to lead the student out of his/her difficulty, and to show the student how to do the problem. A student at the other end of the continuum subscribes to the belief that learning requires a very active role on the part of the student, that the role of the teacher is more to assist and to guide rather than to "pour in" the knowledge.

The fifth belief measured has to do with the students' conceptions of the nature of mathematics. This measure was obtained by asking students the extent of their agreement or disagreement with several questions from the Third National Mathematics Assessment (NAEP, 1983), for example, "Mathematics is made up of unrelated topics" and "Mathematics helps a person to think logically."

Another affective variable which is receiving increasing attention in the mathematics education research literature is the pattern of the students' attributions, both for success and for failure (Meyer & Fennema, 1985; Kloosterman, 1985). Briefly, attribution theory holds that when persons succeed or fail at a task they tend to attribute the success or failure to various factors, for example, their effort, their ability, luck, or

help from others. In this study, students were asked to make attributions for when they do well and do poorly in mathematics. A higher score on the measure indicates attributions to uncontrollable factors (e.g., ability) while a lower score indicates attributions to controllable factors (e.g., effort).

Findings

Attitudes and performance

To assess the relationships between the variables in the study and performance in the course, the data were examined in several ways. First, individual Pearson correlations between the variables in the study and performance in the course (shown in the table below) were computed. Correlations significant below the .01 level are shown in bold face. The correlations show that the strongest individual predictors of performance were the measures of students' ability and one of the measures of confidence, the students' predicted grade in the course. Of the remaining affective variables, only the students' attributions for success were significant below the .01 level.

Table 1
Pearson correlations between independent and dependent variables

	DIAGC	DIAGM	PRED	CON	USE	IEM	CP	MEM	MATH	ATTS	ATTF	ANX
EXAM	.40	.56	.39	.14	-.09	.15	.08	.04	.05	-.24	-.25	-.05

To assess the influence of all the attitudes on achievement, a regression analysis was performed in which the two measures of ability were entered and then all the attitudes were entered as a group. The results (shown in the table below) show that the constellation of attitudes explains a significant percentage of the variance in performance above that explained by the students' ability.

Table 2
Influence of ability and all attitudes on performance¹

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
ABILITY	.3424	21.83	.000	2	78
ATTITUDES	.4805	3.30	.002	11	69

Next, a stepwise regression analysis was performed to determine the most influential variables in the study. The results of that analysis (shown in the table below) show that the students' ability accounted for over 32% of the variance in performance in the course. Four attitudes--both measures of confidence, students' attributions for success, and students' beliefs about the role of memorization and understanding--added significantly to the regression equation and increased the total percentage of the variance explained to 54%.

Table 3
Stepwise regression of influence of ability and attitudes
on performance

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
DIAGM	.3255	28.50	.000	1	56
PRED	.4172	9.81	.003	2	55
ATTS	.4766	7.24	.009	3	54
CON	.5138	5.12	.028	4	53
MEM	.5437	4.48	.039	5	52

In summary, the measures of students' ability were the strongest predictors of performance in the course, which is to be expected. Four attitudinal variables significantly increased the amount of variance explained in the students' performance. However, none of the beliefs variables showed much predictive power. The students' conceptions of intelligence showed only a modest Pearson correlation with performance and the students' beliefs about the role of memorization and understanding also contributed modestly to the regression equation. This was disappointing for it had been felt that in a remedial course with a strong focus on problem solving, poor beliefs might be strongly related to poor performance.

Even working backwards, by comparing data between students who did well in the course and students who did poorly (see Appendix B), the most

significant differences found were in the scores on the two diagnostic tests and predicted grade for the course. Differences in attributions and conceptions of intelligence were found but these were of a smaller magnitude. Average scores on other attitudes were either similar, or in a few cases, the attitudes scores of less successful students were even higher.

Although it is possible that refining the beliefs constructs and obtaining more accurate measures of the beliefs might produce better results, examination of the qualitative data show significant numbers of successful students with "poor" beliefs and significant numbers of unsuccessful students with "good" beliefs. Thus, the premise that the relationship between beliefs and performance is linear seems highly unlikely. In other words, the question to be posed may not be so much which beliefs undermine performance but rather for whom or in what situations will beliefs or other attitudes undermine performance.

Let us now focus on the second question of the study to examine both the quantitative data and the qualitative data to determine whether ability and attitudes have a differential influence on different groups of students.

Males and females

Analysis of the mean scores of females and males on the measures of ability and attitudes (see Appendix B) yielded a significant difference for only one variable, confidence in learning mathematics ($t = 2.54$, $p = .012$), although the means of the males' and females' predicted grades for the course were virtually identical. This is consistent with the findings of Eccles et al. (1983) who found that, in general, males tend to report more

confidence in mathematics than females, but that in the context of a specific course there are not significant differences.

Next, one-tailed Pearson correlations between the variables in the study and performance were computed and are shown in the table below. Correlations significant below the .01 level are in bold face. From the table we see that the measures of ability and both measures of confidence show much greater predictive power for males than for females. Additionally, almost all of the correlations between the attitude variables and performance were higher for the females than for the males. Thus, although the average scores on the attitude measures were similar for both groups, the interaction among the variables seems to differ substantially.

Table 4
Pearson correlations for females and males

	DIAO	CON	PRED	ATTS	ATTF	IEM	CP	MEM	MATH	ANX	USE
FEMALES (N = 82)	.49	.07	.25	-.32	-.25	.15	.08	.10	-.07	-.12	-.10
MALES (N = 63)	.68	.30	.56	-.15	-.24	.11	.05	-.05	.22	.06	-.07

To determine if there were differences in the combined influence of the variables on performance, regression analyses were performed separately for females and males. The results, in the table below, show striking differences between males and females. Ability explains a substantially greater amount of variance in performance for males than it does for females. Additionally, both the measures of confidence and four attitudinal measures (ATTS, IEM, CP, and MEM) contribute significantly to predicting

performance for females but not for males. The magnitude of the differences between males and females was surprising enough to warrant examination of the regression data to discern if other factors, not in the study, might be operating in a systematic manner. However, scatterplots of the residuals in the regression equation were distributed randomly.

Table 5
Regression tables for females and males

	ADJ R SQ	F CH	SIG CH	DF	RESIDUAL
FEMALES					
ABILITY	.1603	7.01	.002	2	61
CONFIDENCE	.2325	3.87	.026	4	59
OTHER ATTITUDES	.3019	2.47	.056	8	55
MALES					
ABILITY	.5062	28.17	.000	2	51
CONFIDENCE	.5302	2.30	.111	4	49
OTHER ATTITUDES	.5042	0.36	.837	8	45

Students of different ability

Another area where different dynamics seemed to be operating was in students of different ability. While reading the students' responses to two of the essay questions (see Appendix A), it was discovered that a surprising

number of students doing well in the course had very poor attitudes and also that a surprising number of students doing poorly in the course seemed to have quite good attitudes. Since the responses are rather provocative, several have been reproduced below. Consider the first question in Appendix A. Below are the responses of two students who did well in the course and the responses of two students who did poorly in the course. The students final grade in the course is in parentheses at the end of the quotation.

"I find it easier to learn the formula which, at first, usually does not make sense. After learning (i.e., memorizing) I do a number of problems using the formula so it does make sense. I think it's easier for me to know the general format and not to waste time trying to understand it. I need to know the basics and work on my own pace from there." (A)

"The strategy I use in solving those kinds of problems is to memorize the formulas or technique at first even if it doesn't make sense until the formula sinks in. Maybe this is the reason I'm not very good in math. I don't think I have the patience to try and see if the formula makes sense. I beleive that it probably will make sense after awhile." (A)

"I find it best to keep trying to understand the concept or technique until it makes sense. I don't prefer to do problems until they sink in because I'd get more confused and lose the whole concept of the original formula. I'd rather understand it and take the problem from there." (C)

"I am used to trying to understand the concept or technique until it makes sense. I can't memorize the formula first and then try the problem if it doesn't make sense to me." (CD)

Let us now look at several responses to the second essay question in

Appendix A.

"I feel that if a student repeatedly achieves the correct answer then he is obviously understanding the material. And if he is comprehending the work and getting the right answer there really isn't any need for explanation." (A)

"Yes, if a student gets an answer without really knowing how, he shouldn't have to explain himself." (B)

"In a way both do have merit, but I do favor the teacher's point of view because I've been in the position where I can do some of the problems because I understand the basic concept. Then, as soon as a hard problem comes along, if I'm missing one piece to the answer I fail at the problem. So I think it's better to make sure that the student can explain in full the technique." (D)

Karen (F). "I think it's a good idea for teachers to ask students to show them how they got their answers. Because if a student gets a right answer but the wrong technique, this could cause a lot of problems. They may have just been lucky with that right answer." (F)

From the examination of these responses and other data came the hypothesis that perhaps attitudes exert a differential influence on students of different ability. To examine this hypothesis, the students were placed according to their combined scores on the two diagnostic tests into three groups--low, medium, and high ability. In the table below, the one-tailed Pearson correlations are shown and those significant below the .01 level are shown in bold face. Given the relatively small numbers of students in each group, the following data can only be seen as exploratory. The table shows some striking differences which, if replicated, may do much to explain the

generally low correlations found between attitudes and performance.

Table 6
Pearson correlations between attitudes and performance
for students of different ability

	DIAO	CON	PRED	ATTS	IEM	CP	MATH	ANX	USE
LOW ABILITY (N=48)	.48	-.13	.30	-.27	.16	.22	.19	.32	-.11
MEDIUM ABILITY (N=61)	.22	.13	.41	-.34	.17	.09	-.04	-.39	-.03
HIGH ABILITY (N=36)	.35	.20	.32	-.13	.19	.00	.21	-.16	-.04

First, it seems that ability is much less related to performance for students of medium ability than for the other two groups. For the other two groups, and for the entire sample, ability was the most powerful predictor of success. For students of medium ability, it is only the fourth most powerful individual predictor. Also, only three variables recorded consistent correlations across all three groups--predicted grade for the course, conceptions of intelligence, and perceived usefulness of mathematics. The coefficients for all the other variables varied considerably.

The most surprising correlation is with respect to anxiety. For students of medium and high ability, anxiety is inversely related to performance, that is, higher anxiety is associated with lower performance and lower anxiety with higher performance. However, for the students of lowest ability, anxiety showed a strong **positive** correlation with performance. It is possible that for many students of low ability taking the course, anxiety might have more of a facilitative rather than a debilitating

effect.

The findings from this part of the study lend support to the hypothesis that better understanding of the influence of attitudes on performance in mathematics may come from analyzing the influence of attitudes on specific kinds of students rather than on the general population. For example, it might be true that students of higher ability with high confidence will do well regardless of their attitudes or, in the context of this study, in spite of poor attitudes. Similarly, it might be true that students of lower ability with low confidence may do poorly in the course even if their attitudes in other areas are excellent.

Three types

It was mentioned earlier that the third source of data for the study were sixteen interviews with students doing poorly in the course just after the first exam. From the analysis of those interviews, another framework for viewing the relationship between attitudes and performance in mathematics, which is in the early stages of development, is emerging.

In culling through the data from the interviews, it was found that the sixteen students showed practically as much variance on each attitude as was found in all 145 students in the course. Their predicted grade for the course ranged from a CD to an AB (the class range was from D to A). Their scores on the conceptions of intelligence measure ranged from 1.5 to 4.5 (the class range was 1 to 5). Their levels of anxiety ranged from 2 to 7 (the class range was from 1.8 to 7). The data points away from a simple, clear relationship or at least a linear relationship between attitudes and achievement.

The change in perspective came from going to the psychology literature to help understand what dynamics might be operating. A key concept in this change in perspective came from the work of Dweck and her associates (Dweck & Elliott, 1983; Dweck & Bempechat, 1982). An essential assumption made by Dweck in her studies with helpless students, and again in her studies examining the effect of different conceptions of intelligence, is that certain beliefs make some students more vulnerable than other students. For example, consider two students who are struggling in math, one of whom favors an entity conception of intelligence while the other favors an incremental conception of intelligence. Dweck asserts that the former student is more vulnerable than the latter because the entity conception of intelligence conflict with the motivation to continue to persevere. However, the latter students' conception of intelligence positively reinforces the motivation to persevere.

With this idea of vulnerability in mind, I looked through the sixteen interviews, writing beside each student's name words or phrases which seemed to capture what was standing in the way of their doing better. At this point, six different 'types' of vulnerable students are emerging, each of which calls for different responses and strategies on the part of the teacher. Following is a brief description of each of the types. Though it is beyond the scope of this paper to go into detail for all six types, the first three types mentioned will be discussed in fuller detail and exploratory data from the study discussed. The helpless student--entity conception of intelligence, low confidence, and attributions for success and failure to uncontrollable factors. The 'denial' student--low skills yet high confidence. The pressured student--high anxiety and high perceived usefulness of math.

The 'don't care' student--low perceived usefulness, low anxiety, and who usually 'hates' math. The naive student--low scores on the beliefs variables; in other words, a student who has not thought very much about the processes involved in learning mathematics.

The helpless student essentially has little or no confidence that his/her effort alone will be sufficient to learn the material. Such a student often gives up very easily, after only minimal effort. Helpless students often make statements like the following. "I'm just no good in math." "I'm dumb in math." "My mind just goes blank." "The only way I'll pass the class is by getting lots of help." There is a rich literature in psychology on learned helplessness (see Seligman, 1975; Diener & Dweck, 1978) and a growing literature in mathematics education on helplessness (see Dweck & Wortman, 1982).

The most succinct description of the second type of student is denial. There seem to be two basic types of denial in students. Some students insist that they really know the material but just make "lots of little mistakes." For example, one of the students in the interviews said he thought his grade at the time of the interview was "either a low C or a CD." When asked what his strengths were as a math student, he replied that he really knew the basics. In fact, he had received a 25% on the first exam and had not passed any of the five chapter quizzes. Another pattern of denial is referred to in the psychology literature as "defensive attributions." Following are several statements such a student is likely to make: "I didn't feel good on the day of the test." "I can't learn from this teacher (this book, this system, etc.)." "I didn't have enough time to do the test (to do the assignment)." As with helplessness, there is a rich psychological literature

pertaining to denial (see Jones & Berglas, 1978).

At the heart of both helplessness and denial is the desire to preserve one's self-esteem. The helpless student truly feels stupid, at least in math. The act of giving up, the helpless posture, can be seen as "cutting one's losses." Since the student feels that perseverance won't pay off anyway, by not seriously engaging with the material, the helpless student at least reduces the frequency and intensity of times of feeling so stupid. The denying student, on the other hand, refuses to acknowledge his/her lack of mathematics skills. Should such a student do poorly in the course, the student has a number of alternative explanations rather than "I cannot learn this material."

A third type of student I have called pressured. This includes the classic "math anxious" student but goes deeper into the causes of anxiety, which often have to do with either having to get a good grade in the course or needing to master the material in the course for some specific reason. The pressured student is likely to make statements like the following. "I have to get at least a B in this class." "I've got to learn this stuff because I have to take statistics (calculus) next semester." "I've got to have a high GPA for graduate school." Pressured students are generally "answer" and "grade" oriented. The analogy to a horse with blinders come to mind. Just as that horse cannot see the surrounding environment, the pressured student misses many cues in the mathematical environment (e.g., similarities from one problem to another and heuristics which can be applied to many types of problems) because s/he is so preoccupied with getting the answer, applying the algorithm, or getting the desired grade.

Although the present study was not designed with these types of

students in mind, an attempt was made to operationalize these three types based on the variables in the study so that some preliminary data might be obtained. Keeping with the underlying concept of vulnerability, it was decided to consider only students whose combined diagnostic score was below the mean score for all students. It was also decided to operationalize each type so that none of the categories contained over 15 students. Otherwise, there would likely be significant overlap between each category which would reduce the distinction between categories. Helpless students were defined as those whose scores on both measures of confidence were low. The heart of the denial process is a unwarranted (public) confidence in one's ability. A rough measure of this unwarranted confidence was constructed by subtracting the combined diagnostic test score from the difference between the student's predicted grade in this course and reported grade in the student's previous class. The pressured type was defined as a student who reported both high levels of anxiety and high levels of usefulness of mathematics.

The table in Appendix C shows the mean scores of the dependent and independent variables for all students and for each of the three types. The variables used to define each type are in parentheses above each type. Descriptive statistics tell only part of what might be happening (recall the case of the males and females where the means of the attitudes were not very different). However, the table shows some interesting patterns.

The helpless students show the highest degree of attributions to uncontrollable factors. They also show significantly lower scores on all of the beliefs measures which was expected. For example, the lower score on the conceptions of intelligence measure indicates more focus on entity than

incremental conceptions of intelligence. Similarly, the lower score on the learning goals measure indicates a greater focus on avoiding a poor grade than on becoming more competent in mathematics.

The denial students do not differ from the whole population on their patterns of attributions, perceived usefulness of mathematics, or anxiety. However, on some of the beliefs measures their responses actually indicate better beliefs.

For the pressured students, the most significant items were their predicted grade in the course and their confidence in their ability to learn mathematics. In general, the means for these two scores were very close. However, the pressured students' predicted grade was much higher than their confidence in their ability to learn mathematics. This might indicate that because they see mastery of the material in the course as necessary, they feel a need to do well but they do not have much confidence that they will do well.

As stated above, this framework on different types is still being developed. Future research will deepen our understanding of each type, how such attitudes undermine the student's ability to learn mathematics effectively, and the teacher interventions and strategies which might be most productive. Although most of a teacher's attention should necessarily be in the direction of increasing the student's cognitive and metacognitive skills, focus on these types can enable teachers also to address the psychological-motivational factors which impede such students' abilities to learn mathematics effectively.

Conclusion

The findings from this study support the conclusion from the literature that, in general, attitudes are not significant predictors of performance in a mathematics course. However, the study has produced evidence that one cause for these generally low correlations between attitudes and performance may be that attitudes interact differently for different groups of students--for example, males and females and students of different ability. Finally, the study has proposed a new framework for investigating the influence of attitude on performance, by looking at different types of students and how their attitudes might be undermining their ability to do well in mathematics courses.

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Appendix A
Two essay questions

1. When struggling to learn a new concept or formula (for example, solving equations or percent problems) there are a variety of learning strategies. Some students find it best to memorize the formula or technique at first even if it doesn't make sense. After doing a number of problems, the formula or technique "sinks in." Other students find it best to keep trying to understand the concept or technique until it makes sense. Once it makes sense the problems are easier to do. Which strategy are you most likely to follow? Explain. If neither strategy fits you, explain how you usually go about learning new concepts and formulas.

2. Some teachers are not content just because you get the right answer. They also focus on understanding how you got the answer. Such teachers feel that sometimes students just memorize the correct technique for doing a problem without really understanding what they are doing. On the other hand, students often feel that such teachers are being too picky. The students maintain that sometimes you know what you are doing even if you can't explain it in words. They feel that if you know how to use the technique and can get the right answer, that's sufficient. Do you favor one position over the other or do you believe both positions have merit? Explain.

Appendix B
Descriptive statistics for different groups of students

	ALL	FEMALE	MALE	A	CD OR LOWER
N	145	82	63	21	34
DIAG(C)	5.12	5.08	5.16	6.31	4.76
DIAG(M)	4.20	4.30	4.08	5.45	2.97
PRED	2.92	2.93	2.92	3.30	2.62
CON	2.71	2.53	2.94	2.89	2.62
ATTF	0.73	0.68	0.80	-0.09	0.92
ATTS	1.87	1.90	1.84	0.95	2.05
IEM	3.40	3.51	3.26	3.72	3.23
PC	3.09	3.19	2.95	3.21	3.03
ACTIVE	3.44	3.36	3.55	3.39	3.52
MEM	3.11	3.09	3.13	3.23	3.32
MATH	3.48	3.51	3.43	3.68	3.50
USE	3.88	3.88	3.86	3.74	3.98
ANX	4.81	4.76	5.81	4.95	4.67
EXAM	69.4	71.1	67.3	85.8	51.1
GRADE	2.79	2.91	2.63	4.00	1.47

Appendix C
Descriptive statistics for the three types

	ALL	(Low PRED & CON) HELPLESS	(High DENIAL) DENIAL	(High USE & ANX) PRESSURED
N	145	15	15	11
DIAG(C)	5.12	4.20	3.80	4.00
DIAG(M)	4.20	2.80	3.27	3.36
PRED	2.92	1.89	3.03	2.66
CON	2.71	1.10	2.73	1.93
ATTF	0.73	1.07	0.87	0.91
ATTS	1.87	3.13	2.00	2.90
IEM	3.40	2.63	3.47	3.73
LG	3.09	2.63	2.90	2.90
ACTIVE	3.44	3.05	3.59	3.43
MEM	3.11	2.78	3.20	3.43
MATH	3.48	3.36	3.64	3.48
USE	3.88	3.80	3.83	5.36
ANX	4.72	5.21	5.07	5.94
EXAM	69.4	60.0	63.9	63.9
GRADE	2.79	2.50	2.43	2.55

Footnote

¹The terms in the regression tables include (ADJ R SQ) the adjusted r square value which indicates the amount of variance in the dependent variable explained by the independent variables, (F CH) the change in the F value from one step to the next, (SIG CH) the significance of this change in the F value, (DF) the degrees of freedom in the equation, and (RESIDUALS) the number of subjects remaining in the analysis.